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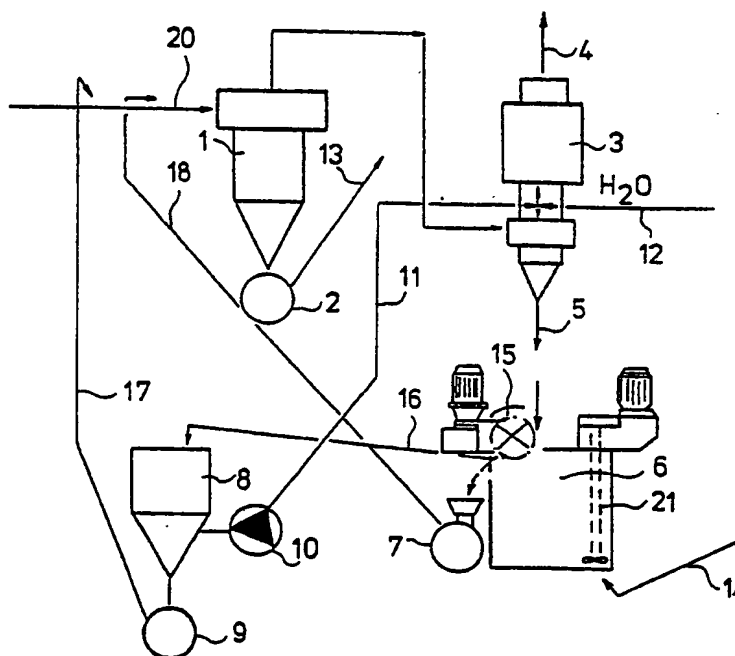
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<p>(21) International Application Number: PCT/FI86/00027 (22) International Filing Date: 19 March 1986 (19.03.86)  (71) Applicant: INSINÖÖRITOIMISTO LISOP OY [FI/ FI]; PL 52, SF-04201 Kerava (FI). (72) Inventor: JÄRVENPÄÄ, Viljo, Juhana ; Vellamontie 21 as 6, SF-04200 Kerava (FI). (74) Agent: FORSSÉN &amp; SALOMAA OY; Uudenmaankatu 40 A, SF-00120 Helsinki (FI).  (81) Designated States: AT (European patent), CH (Euro- pean patent), DE (European patent), DK, FR (Euro- pean patent), GB (European patent), NL (European patent), SE (European patent).</p>		<p><b>Published</b> <i>With international search report. In English translation (filed in Finnish).</i></p>

(54) Title: FLUE-GAS PURIFYING PROCEDURE



(57) Abstract

A wet washing procedure wherein the reaction products, in the first place the sulphur dioxide which has burned with use of lime, react to become Ca-sulphite. This is best oxidized with air. The oxidized gypsum is floated with oxidizing air in a reaction tank (6) and the foam is conducted either into the combustion volume of the combustion boiler or to join the hot flue gases (20) to be purified, whereby liquid emissions are inhibited. The gypsum that has joined the quick ash is separated in a dry separator (1) in dry condition, and possibly a minor part of the quick ash goes once again to the washing, into the liquid and to flotation, and thence further to drying.

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1 Flue-gas purifying procedure

5 The present invention concerns a flue-gas purifying procedure conforming to the introductory part of claim 1.

The nature-polluting effect of the sulphur content in flue gases is nowadays recognized, in Central Europe in particular, to be a  
10 highly troublesome phenomenon. In industrial emissions, for instance, sulphur is burned to sulphur dioxide, and the gaseous sulphur dioxide reacts with moisture to become sulphurous acid and sulphuric acid. Sulphurous acid and sulphuric SALTS, in turn, being  
15 strong acids, react with metal and basic metal or minerals in the soil, and these impurities cause acidification of the soil and depletion of trace elements in the nature.

Research aiming at removal of the detrimental sulphur in flue gases has been going on for quite a long time, and numerous designs  
20 have been worked out in order to reduce these harmful flue gas emissions. It is nowadays generally recognized that electric filtering of flue gases alone is not enough. On the other hand, addition of milk of lime, or  $\text{Ca}(\text{OH})_2$ , into the flue gas volume has been found to produce comparatively good results. This application  
25 of milk of lime is the so-called semi-dry method. It implies that a milk of lime spray is dried with the flue gases, whereat the sulphur dioxide is bound in powder form, and this powder is separated from the flue gases. The drawback of this procedure of prior art is the high cost of the method and the use of a relatively high  
30 excess of lime, or so-called over-stoichiometry, in relation to the sulphur, which results in comparatively large quantities of waste product.

Also known in the art is the so-called floating bed burning method,  
35 in which  $\text{CaCO}_3$  powder is supplied, together with coal powder, into the burning furnace, in which with a powerful air current these

1 materials are maintained in the air current floating in the conical  
part of the furnace. In this procedure of prior art, the coal  
burns and the limestone is converted to the compound  $\text{CaO}$ , which in  
its turn reacts directly with the sulphur which was present in the  
5 coal and has burned. This method is encumbered by the drawback of  
its relatively high cost and of large so-called circulating solid  
matter flows.

In prior art one has also used the so-called wet washing method to  
10 the purpose of purifying flue gases: in this method the flue gases  
are directly washed with alkaline washing water. This procedure of  
prior art is comparatively reliable, and it is possible in this  
method to come very close to stoichiometry = 1. The drawbacks of  
15 the procedure consist of numerous harmful effects, such as frequent  
plugging, corrosion, wear phenomena and, in particular, large  
water quantities, their collection and conveying to dumps having  
caused major difficulties.

The object of the invention is to achieve an improvement of the  
20 flue gas purifying methods known at present. The more detailed  
object of the invention is to achieve an improvement of the wet  
washing method presently known. The other objects of the invention  
and the advantages gainable by its aid will become apparent in the  
disclosure of the invention.

25 The procedure of the invention is mainly characterized by that  
which is stated in the characteristic features part of claim 1.

The procedure of the invention is simple as to its principle, and  
30 a closed design is employed in it. As taught by the invention,  
flotation of the liquid emerging from the wet washer and of the  
solid matter therein to become separate partial flows, which are  
easy to dry, is a simple but genial insight. When the procedure of  
the invention is applied, the washing fluid quantities above all,  
35 and also the sizes of the tanks required in the apparatus design,  
are reduced to a fraction of those involved in any presently used

1 procedure. It is possible in an advantageous embodiment of the  
invention to recover the impurities carried in the whole flue gas  
quantity, in dry condition and even in chemically bound state  
without even the slightest aqueous emission.

5

The invention shall now be described in detail, referring to the  
principle design presented in the figure of the attached drawing,  
to which however the invention is not meant to be exclusively  
confined.

10

The figure of the drawing presents an advantageous embodiment of  
the apparatus design employed in implementing the procedure of the  
invention, in schematic elevational view.

15

In the embodiment depicted in the figure, the flue gas flow 20 is  
first conducted, advantageously, into a dry separator 1, which in  
this embodiment is a conventional cyclone separator. Part of the  
impurities present in the flue gases depart from the flue gas flow  
20 and run down into the lower cone of the cyclone separator 1,  
whence the dry solid matter may be conducted, with the aid of a  
pressure transmitter 2 located below the cyclone separator 1, as a  
material flow 13 e.g. to a centralized powdery material storage  
container (not depicted).

25

After the cyclone separator 1, the flue gases flow to the wet  
washer 3, where the gaseous components present in the flue gases  
are washed so that the gas flow 4 emerging from the wet washer 3  
will be clean enough. The wet washer 3 is known in the art in  
itself and it may be combined with the cyclone separator, as has  
been shown in the figure of the drawing. The washing water flows  
along the line 12 of the wet washer 3. The spent washing water  
flows from the wet washer 3 to a combined mixing and flotation  
unit 6, in the form of the washing water flow 5.

35

Air is conducted to the mixing and flotation unit 6 by the line  
14, and the mixing and flotation unit 6 is advantageously provided

1 with a mixing means 21. In the mixing and flotation unit 6, the  
sulphite in the washing water, if any, is oxidized to sulphate,  
and the flotation process taking place lifts the reaction and  
washing products that have been formed in the wet washer 3, along  
5 with the foam out from the mixing and flotation unit 6. Such a  
foam remover has been indicated with the reference numeral 15 in  
the figure of the drawing. The foam, with the solid matter and the  
liquid held in the foam, is directed to a pressure transmitter 7  
which has been disposed to guide the separated foam as a flow 18  
10 to join the flue gas flow 20, the flue gas flow 20 having been  
arranged to dry out the liquid held in the foam and, as the flue  
gas temperature usually is in the range of 100 to 240°C, the  $\text{CaSO}_4$   
loses part of its crystal water. The dried solid matter separates  
and ends up among the solid matter in the lower cone of the cyclone  
15 separator 1, in which connection for instance the separated gypsum  
is in the form of a powder hardening powerfully together with  
water and thus is a substance well appropriate to be carried to a  
dump, or to be used otherwise. If desired, facilities for adding  
floculating agent can be provided on the mixing and flotation  
20 unit 6, or a flocculation unit alone may be substituted for this  
unit, depending on what chemicals are used.

The solid matter which fails to be removed from the mixing and  
flotation unit 6 runs as an overflow 16 into the tank 8, where  
25 advantageously with the aid of centrifugal action the solid matter  
is directed to settle in the lower cone of the tank 8. Below the  
lower cone of the tank 8 has been disposed a pressure transmitter  
9, arranged to direct this solid matter in a flow 17 to join the  
flue gas flow 20, whereby the liquid held by the solid matter  
30 evaporates off and the solid matter separates in dry dust form in  
the lower part of the cyclone separator 1, whence the pressure  
transmitter 2 sends the dry solid matter as a material flow 13 to  
the centralized powdery material storage already described.

35 Certain practical facts have to be observed when applying the  
procedure of the invention. When the fuel, coal in the first place,

1 contains 1% sulphur, the quantity of gypsum that has to be dried  
in the procedure of the invention will be 3.5 to 5% of the coal,  
depending on the purity of the lime that is used. The solid matter  
passing through the dry separation varies between 1 and 3% of the  
5 quantity of coal burned, and therefore the quantity of solid matter  
that has to be dried varies between 4 and 8% of the coal quantity.  
This, together with the washing liquid that has to be evaporated,  
lowers the temperature of the flue gas flow 20 by about 10 to 30°,  
depending on the liquid quantity in the material to be dried.

10 It is also possible in the procedure of the invention to direct  
the material flow 17 directly into the combustion boiler, where  
naturally the material flow is heated to a temperature at which  
the gypsum totally loses its crystal water and becomes either  
15 slow-reacting with water or becomes so-called "dead"-gypsum, which  
reacts hardly at all with water. It should be noted, on the other  
hand, that the gypsum is again decomposed to sulphur dioxide, and  
for this reason it is not recommended that the material flow 17 be  
conducted into the combustion boiler, at least not into its hottest  
20 region.

The washing liquid flow 12 contains the requisite neutralizing  
substance, in which capacity  $\text{Ca}(\text{OH})_2$ , or so-called milk of lime,  
serves best. The quantity of milk of lime in the washing liquid is  
25 advantageously monitored so that the mixing and flotation unit 6  
can operate in a pH range of preferably 5 to 9. Naturally, other  
chemicals may be used instead of milk of lime, for instance  $\text{NaOH}$ ,  
or caustic liquor, or  $\text{NaCO}_3$ , or soda, in which case the sulphur  
present in the flue gas flow 20 will react without forming any  
30 solid products. In that case nothing emerges from the mixing and  
flotation unit 6 but the quick ash that has passed through the  
cyclone separator 1.

35 The material flows 17 and 18 dried in the incoming flue gas flow  
20 are separated in the cyclone separator 1 mainly in granulated  
form. It should be particularly noted that the size both of the

1 mixing and flotation unit 6 and the tank 8 is comparatively small  
compared with the liquid tanks in present use. In the procedure of  
the invention, the requirement of fresh washing water, in terms of  
weight, is on the order of the coal quantity (the fuel quantity)  
5 that is fed in.

It is also possible in the procedure of the invention to recover  
heat from the washing liquid. An advantageous way to accomplish  
such recovery is to arrange for a return flow 11 from the tank 8  
10 to the wet washer 3, e.g. by means of a water circulating pump 10.  
It should be noted that, as a rule, the temperature in the tank  
varies: for instance in connection with coal firing, between 40  
and 60°C. The return flow 11 also flushes out impurities from the  
wet washer 3 because the return flow joins the washing liquid flow  
15 5, which is directed to the mixing and flotation unit 6. It is  
thus possible in the procedure of the invention to achieve a so-  
called closed washing liquid circulation.

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## 1 Claims

1. A procedure for purifying flue gases, wherein the flue gas flow (20) containing impurities is conducted into a washer means (3), to which is conducted washing liquid containing chemicals, such as advantageously  $\text{Ca}(\text{OH})_2$ , said washing liquid having been disposed to react with the flue gas flow (20) to be purified, characterized in that the washing liquid which has reacted with the flue gas flow (20) to be purified is conducted to a combined mixing and flotation unit (6), and that the foam emerging from said mixing and flotation unit (6) together with its solid matter and with the liquid held in the foam is conducted as a first flow (18) to join the flue gas flow (20) to be purified or directly into the combustion volume of the combustion boiler, the flue gas flow (20) to be purified having been disposed to dry out the liquid contained in the foam.

2. Procedure according to claim 1, characterized in that the solid matter which fails to leave said mixing and flotation unit (6) has been disposed to go as an overflow (16) to a tank (8), where the solid matter is separated to lodge in the lower part of said tank (8), and that the separated solid matter is directed as a second flow (17) to join the flue gas flow (20) to be purified or possibly directly into the combustion volume of the combustion boiler, whereby the liquid held by the solid matter evaporates off.

3. Procedure according to claim 1 or 2, characterized in that the flue gas flow (20) to be purified is prior to its flowing to the washer means (3) conducted to a dry separator (1), where the dry solid matter contained in the flue gas flow (20) separates.

4. Procedure according to claim 3, characterized in that the flows (17,18) conducted to join the flue gas flow (20) to be purified in order to be dried are conducted to said dry separator (1), where the solid matter contained in said flows (17,18) has been arranged to become separated to join the dry solid matter contained in the

1 flue gas flow (20) to be purified.

5. Procedure according to claim 3 or 4, characterized in that the  
dry solid matter that has separated to lodge in the lower part of  
5 the dry separator (1) is conducted as a material flow (13) to a  
centralized powdery material store.

6. Procedure according to any one of claims 1-5, characterized in  
that the pH range of the mixing and flotation unit (6) is controlled  
10 to keep within a suitable flotation range, preferably in the range  
from 5 to 9, with the aid of a suitable alkali.

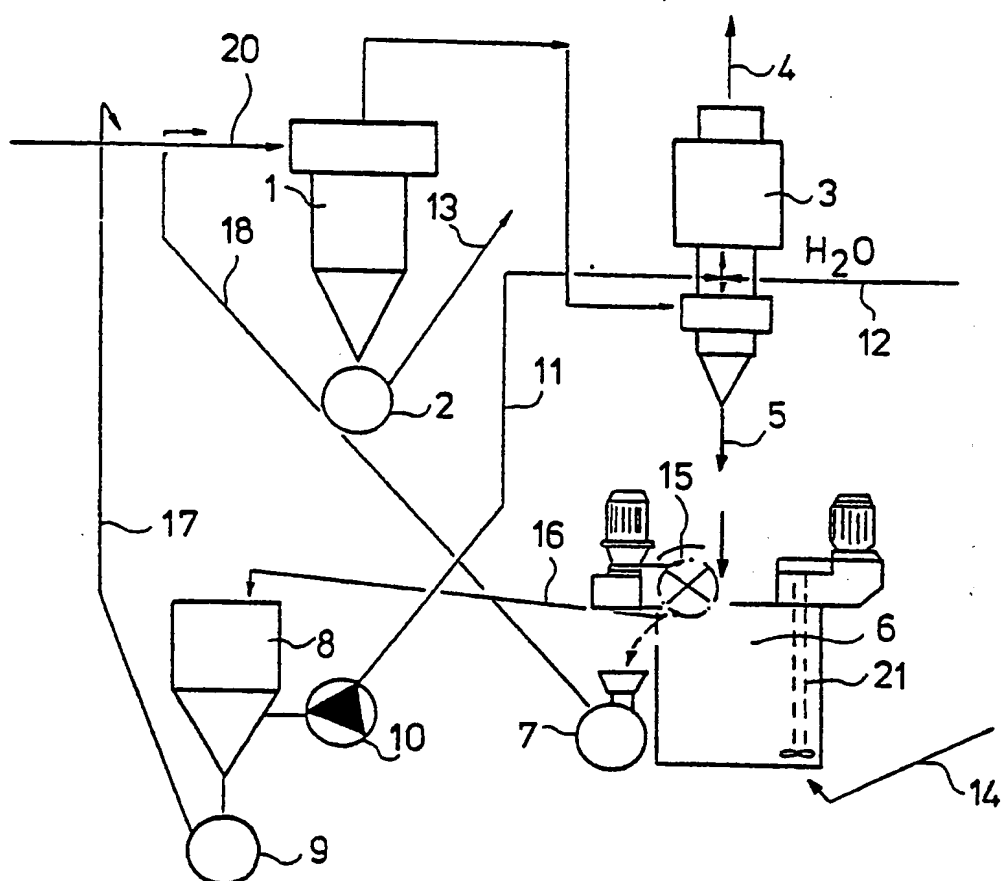
7. Procedure according to any one of claims 1-6, characterized in  
that the spent washing liquid is conducted as a return flow (11)  
15 back to said washer means (3).

8. Procedure according to claim 7, characterized in that the spent  
washing liquid is pumped from said tank (8) with the aid of a  
circulation pump (10) to constitute a return flow to the washer  
20 means (3), the heat contained in the washing fluid being recovered  
at the same time.

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# INTERNATIONAL SEARCH REPORT

International Application No PCT/FI86/00027

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>6</sup> According to International Patent Classification (IPC) or to both National Classification and IPC <sup>4</sup> <div style="text-align: center; font-family: monospace;">B 01 D 53/14</div>																	
<b>II. FIELDS SEARCHED</b> <div style="text-align: center; font-size: small;">Minimum Documentation Searched <sup>7</sup></div> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 30%; text-align: left; font-size: x-small;">Classification System</th> <th style="text-align: left; font-size: x-small;">Classification Symbols</th> </tr> <tr> <td style="vertical-align: top;">IPC US C1</td> <td style="vertical-align: top; font-family: monospace;">B 01 D 53/14, /34; C 01 F 11/46 423:242, 555</td> </tr> </table> <div style="text-align: center; font-size: x-small; margin-top: 10px;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup></div> <div style="text-align: center; font-family: monospace; margin-top: 20px;">SE, NO, DK, FI classes as above</div>			Classification System	Classification Symbols	IPC US C1	B 01 D 53/14, /34; C 01 F 11/46 423:242, 555											
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<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <sup>9</sup> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%; font-size: x-small;">Category <sup>9</sup></th> <th style="width: 60%; font-size: x-small;">Citation of Document, <sup>11</sup> with Indication, where appropriate, of the relevant passages <sup>12</sup></th> <th style="width: 30%; font-size: x-small;">Relevant to Claim No. <sup>13</sup></th> </tr> </thead> <tbody> <tr> <td style="text-align: center; vertical-align: top;">A</td> <td style="vertical-align: top; font-family: monospace;">SE, B, 396 363 (B P B INDUSTRIES LTD) 19 September 1977</td> <td></td> </tr> <tr> <td style="text-align: center; vertical-align: top;">A</td> <td style="vertical-align: top; font-family: monospace;">EP, A1, 108 249 (STEAG AG) 16 May 1984</td> <td></td> </tr> <tr> <td style="text-align: center; vertical-align: top;">A</td> <td style="vertical-align: top; font-family: monospace;">US, A, 4 294 807 (RANDOLPH) 13 October 1981</td> <td></td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td style="vertical-align: top; font-family: monospace;">GB, A, 1 401 682 (FISONS LIMITED) 30 July 1975</td> <td style="text-align: center; vertical-align: middle;">1</td> </tr> </tbody> </table>			Category <sup>9</sup>	Citation of Document, <sup>11</sup> with Indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>	A	SE, B, 396 363 (B P B INDUSTRIES LTD) 19 September 1977		A	EP, A1, 108 249 (STEAG AG) 16 May 1984		A	US, A, 4 294 807 (RANDOLPH) 13 October 1981		X	GB, A, 1 401 682 (FISONS LIMITED) 30 July 1975	1
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<b>IV. CERTIFICATION</b> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;">           Date of the Actual Completion of the International Search  <div style="font-family: monospace;">1986-10-01</div> </td> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;">           Date of Mailing of this International Search Report  <div style="font-family: monospace;">1986 -10- 08</div> </td> </tr> <tr> <td style="border-bottom: 1px solid black; padding: 5px;">           International Searching Authority  <div style="font-family: monospace;">Swedish Patent Office</div> </td> <td style="border-bottom: 1px solid black; padding: 5px;">           Signature of Authorized Officer  <div style="font-family: monospace;">               Britt-Marie Lundell           </div> </td> </tr> </table>			Date of the Actual Completion of the International Search <div style="font-family: monospace;">1986-10-01</div>	Date of Mailing of this International Search Report <div style="font-family: monospace;">1986 -10- 08</div>	International Searching Authority <div style="font-family: monospace;">Swedish Patent Office</div>	Signature of Authorized Officer <div style="font-family: monospace;">               Britt-Marie Lundell           </div>											
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